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A Study of the New Cataclysmic Variable 2MASS 23212116+3807563

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We present our variability study of the new cataclysmic variable star, 2MASS 23212116+3807563. The variable is a U Geminorum type star. An analysis of available electronic archives data (CSS, 1SWASP and ASAS-SN) does not detect periodicity. The variable has a close companion, photometric data in the electronic archives present combined light of the two stars. We acquired the star's new CCD photometry in Johnson's B, V, and R bands. Our observation confirm variability of 2MASS 23212116+3807563 with a large amplitude of light variations (more than 3^m).

1 Discovery of variability

In the course of our search for variable stars in available electronic archives, we suspected variability of the object NSVS 3597160 in the ROTSE-I/NSVS data base[1] (Wozniak et al. 2004).

This NSVS number corresponds to GSC 03230-01273. It is actually a close pair not resolved in the GSC, GSC2.2, GSC2.3, USNO-A2.0, or USNO-B1.0 catalogs. The pair is, however, resolved in the 2MASS (Skrutskie et al. 2006) and UCAC4 (Zacharias et al. 2012) catalogs: 2MASS 23212116+3807563 and 2MASS 23212148+3807581 ($d = 4\farcs16$), UCAC4 641-126371 and UCAC4 641-126372 ($d = 4\farcs00$).

We confirmed variability of the pair using data from the 1SWASP survey[2] (Butters et al. 2010) and Catalina Surveys[3] (CSS, Drake et al. 2009). In these data, the pair is not resolved. The CSS measured the combined light of the star pair (the variation range $13\fm52-14\fm38$, CV) and the 1SWASP, of the star pair plus, additionally, GSC 03230-01144 (variations in the $13\fm3 - 13\fm8$ range).

Later, we identified the actual variable star from our CCD observations: the component of the pair 2MASS 23212116+3807563 = UCAC4 641-126371 varies. Its coordinates are: RA = $23^h21^m21\fs19$, Dec = $+38°07'56\farcs2$ (J2000).

The new data of the All-Sky Automated Survey for Supernovae[4] (ASAS-SN, Shappe et al. 2014; Kochanek et al. 2017) are measurements of the combined light of the star pair ($13\fm7 - 14\fm9$, V); they confirm the variable's classification as a cataclismic star.

In July 2018, T. Kato reported the variability of the GSC 03230-01273 pair (vsnet-chat#7934, vsnet-chat#7940), identified the actual variable with Gaia DR2 J232121.194+380756.07, and classified it as a dwarf nova star. On the base of these

[1] http://skydot.lanl.gov/nsvs/nsvs.php
[2] http://wasp.cerit-sc.cz/form
[3] http://nunuku.caltech.edu/cgi-bin/getcssconedb_release_img.cgi
[4] https://asas-sn.osu.edu

reports, the star was included into the AAVSO/VSX[5] data base (type UG, range 14.2–16.1:, V).

2 Observations and data reductions

We acquired new CCD observations of the area of the GSC 03230-01273 pair. Our photometric data in the standard Johnson B, V and R bands were performed at the Tien Shan Astronomical Observatory of the V.G. Fesenkov Astrophysical Institute, at the altitude of 2750 m above the sea level. The time span of the observations is JD 2456571 – 2457031 (October 5, 2013 – January 8, 2015). The observatory has two Zeiss 1000-mm telescopes. Most of the observations were performed at the "eastern Zeiss" telescope (the focal length of the system was $f = 6650$ mm, the detector being an Apogee U9000 D9 CCD camera). During the time interval JD 2456948 – 2456958, we used the "western Zeiss" 1000-mm reflector ($f = 13250$ mm; Apogee F16M CCD camera). During two nights (JD 2456959, and JD 2456963), we used both telescopes.

Information on the comparison star and check star used in our CCD photometry is presented in Table 1. The magnitudes of the comparison star are from the AAVSO Photometric All-Sky Survey (APASS[6]) catalog. The finding chart (Fig. 1) identifies the variable star and the comparison star. The light curves of the variable from our CCD data in three bands are displayed in Fig. 2. The R-band observations could be presented only as magnitude differences with an arbitrary zero point.

Table 1. Comparison and check stars

Comparison star	Name	GSC 01320–01144
	Coordinates, J2000.0	$23^{\rm h}21^{\rm m}21\overset{\rm s}{.}82$ $+38°08'28\overset{''}{.}6$
	V, mag	$14\overset{\rm m}{.}093$
	B, mag	$14\overset{\rm m}{.}763$
Check star	Name	GSC 03230–01746
	Coordinates, J2000.0	$23^{\rm h}21^{\rm m}31\overset{\rm s}{.}46$ $+38°05'43\overset{''}{.}8$

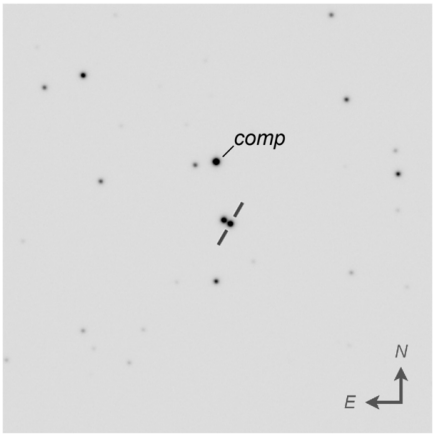

Figure 1. The finding chart of 2MASS 23212116+3807563 (V band, $4' \times 4'$).

[5]http://www.aavso.org/vsx/
[6]http://www.aavso.org/download-apass-data

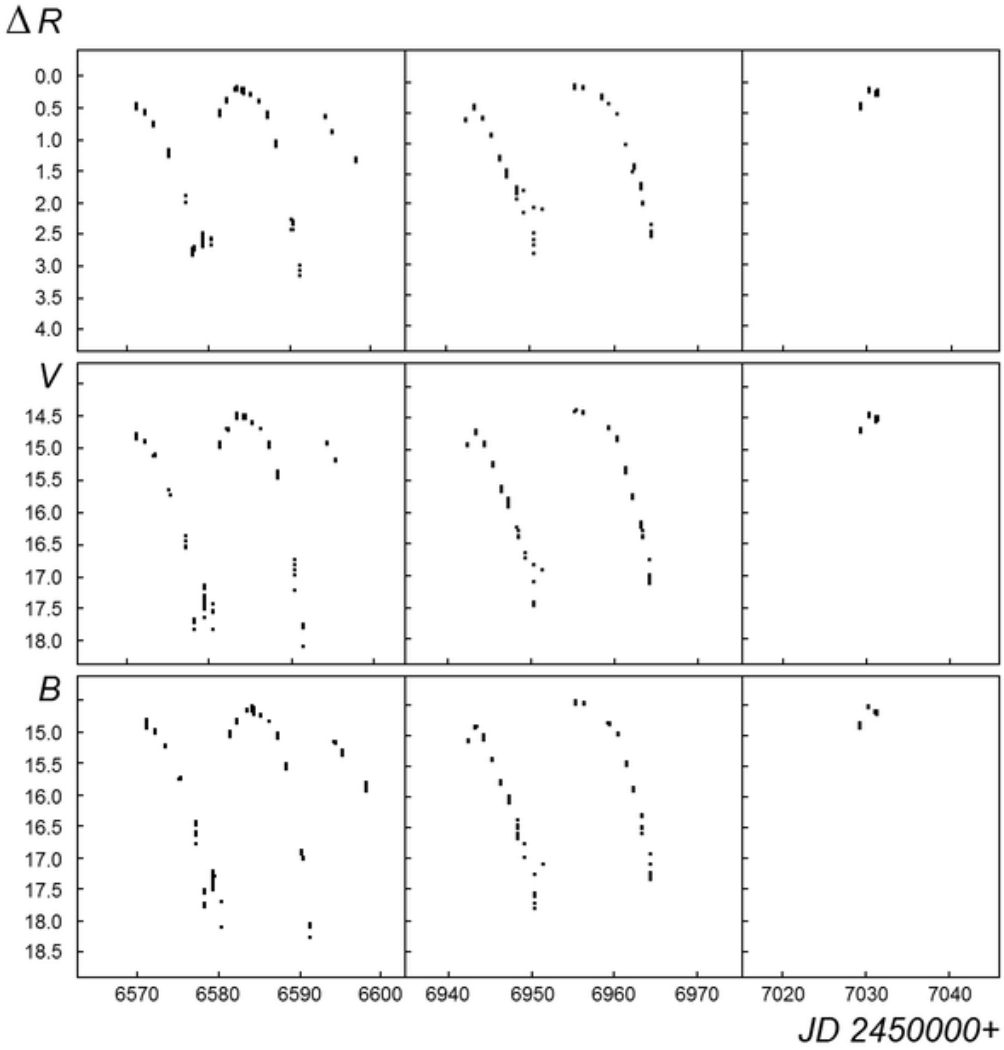

Figure 2. The light curves of 2MASS 23212116+3807563 from our CCD data in the R, V and B bands.

Reductions were performed using the MaxIm DL Version 5.23 aperture photometry package. We were able to clearly resolve the GSC 03230-01273 pair not on all nights. It was especially difficult to resolve it near the brightness minimum; distorting influence from the wings of the bright constant companion, with the variable not clearly seen against them, resulted in the measured brightness of the variable being strongly overestimated. Thus, we measured the light of the bright component very accurately, during the time intervals of the lowest brightness of the variable object. With this knowledge, we analyzed combined brightness of the pair and found the brightness of the variable component. In future, we are planning to use PSF photometry for our studies of this object.

Our observations are available online in the html version of this paper.

3 Data from photometric archives

For our analysis, we used data from three photometric archives of automatic surveys. In all of them, the light of two or more stars was actually measured, resulting in the variability amplitude being underestimated very strongly. Rapid brightenings, about 1–2

days in duration, are clearly seen in the 1SWASP data (JD 2453910–2454450); they are typical of U Geminorum stars. The light curve from 1SWASP observations is presented in Fig. 3. The CSS data (JD 2453628–2457388) show irregular variations: the intervals between observation are longer than the mean variability cycle. The light curve from the CSS observations is displayed in Fig. 4.

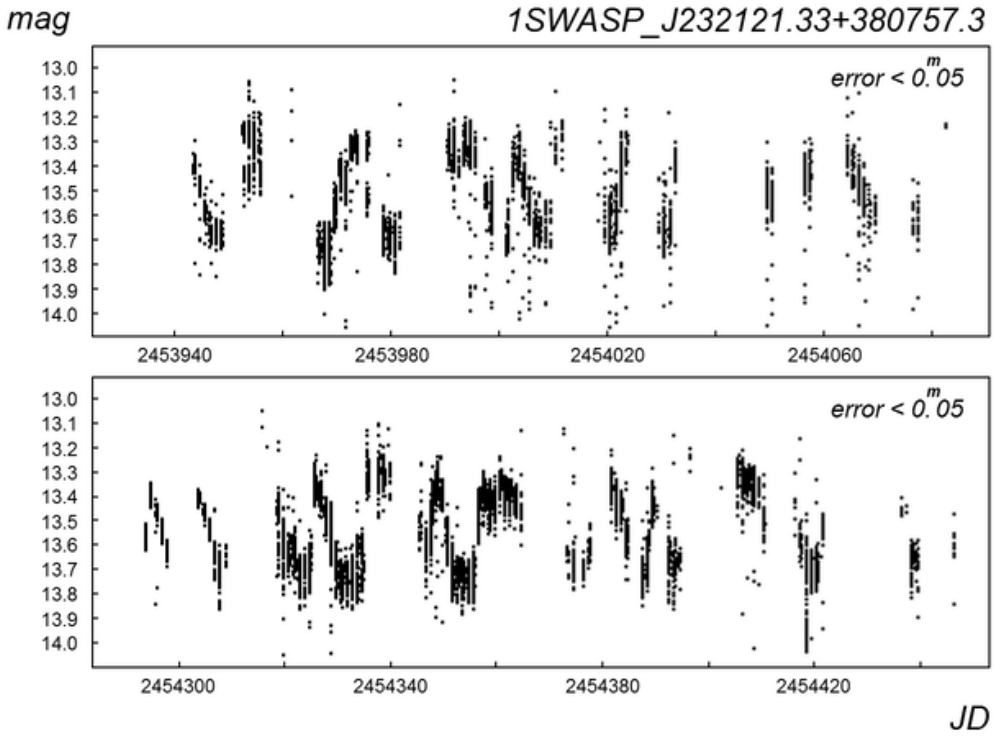

Figure 3. The light curve of 2MASS 23212116+3807563 from 1SWASP data.

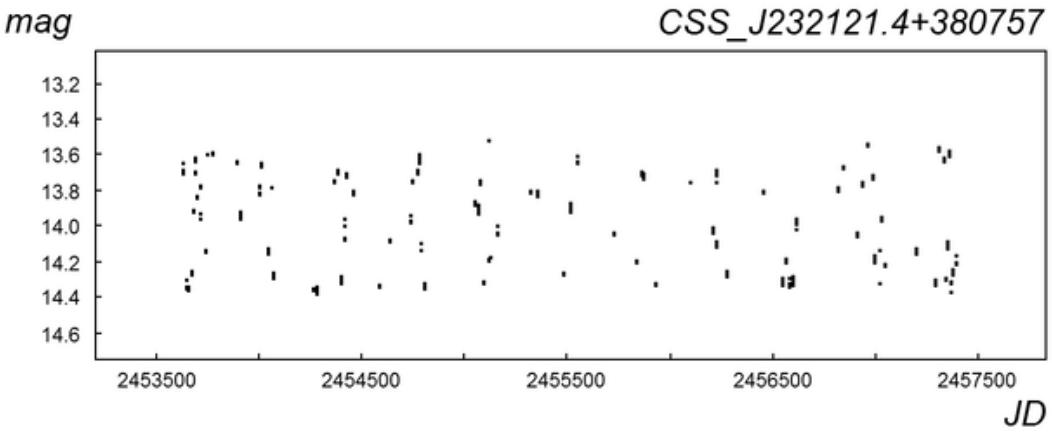

Figure 4. The light curve of 2MASS 23212116+3807563 from CSS data.

The ASAS-SN data provide the longest time span of observations. In these data, individual cycles are very clearly visible; it is possible to count the number of outbursts during observation seasons. The light curve from ASAS-SN data is presented in Fig. 5.

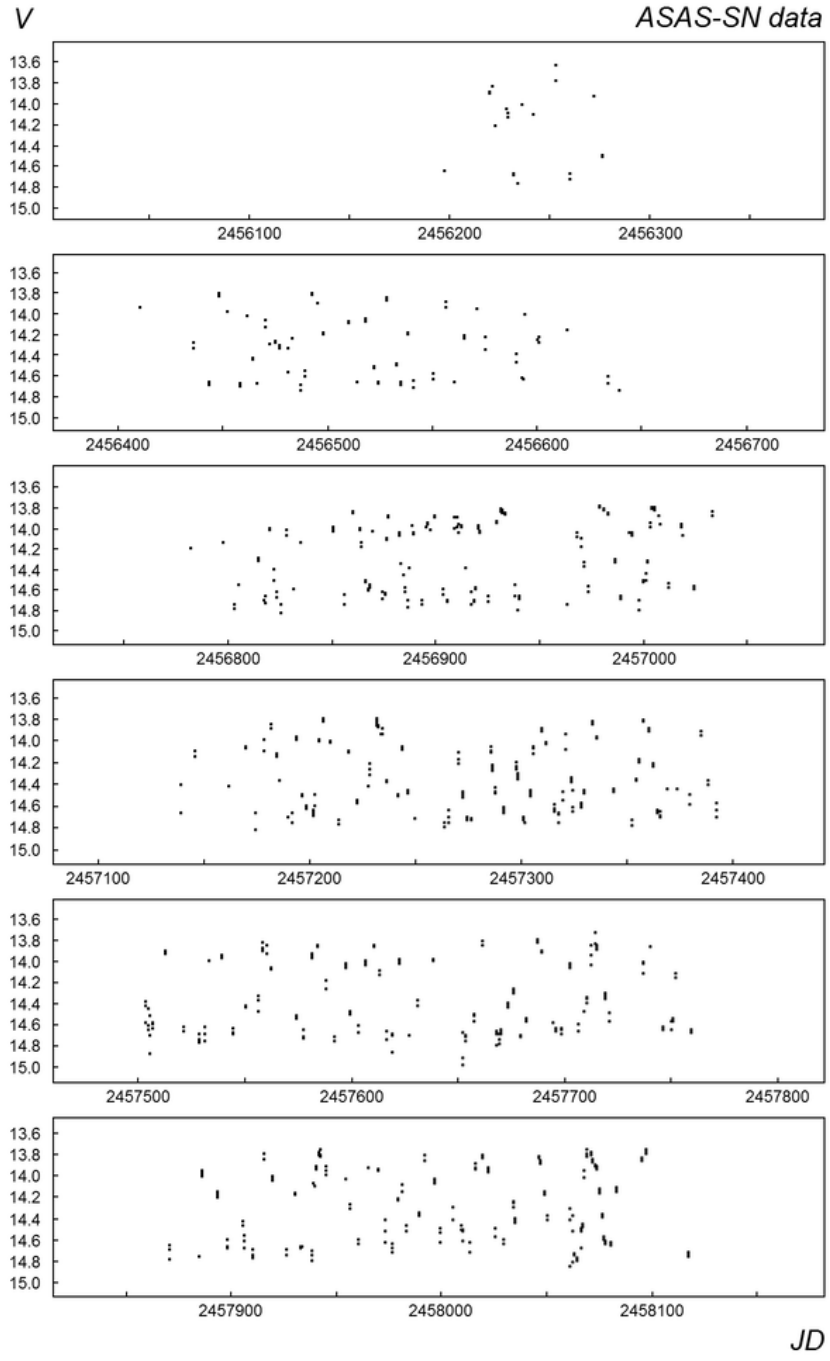

Figure 5. The light curve of 2MASS 23212116+3807563 from ASAS-SN data.

We analyzed the data available in the electronic archives (1SWASP, CSS, and ASAS-SN) using two methods implemented in the WinEfk code[7] written by V.P. Goranskij: the Deeming method (Deeming 1975) and the Lafler–Kinman method (Lafler & Kinman 1965). We did not find a strict period of the light variations and determined only mean cycles for different data series.

[7] http://www.vgoranskij.net/software/

4 Results

From our period analysis, according to the 1SWASP data, the mean cycle is 10 days. From the ASAS-SN data, we estimated, by cycle counts, the following mean cycles for individual seasons (the cycles in brackets are the most probable ones as determined using the Deeming method):

season 2, JD 2456410–2456640: $12\overset{\mathrm{d}}{.}3$ (−);
season 3, JD 2456780–2457040: $10\overset{\mathrm{d}}{.}9$ ($12\overset{\mathrm{d}}{.}1$);
season 4, JD 2457130–2457400: $12\overset{\mathrm{d}}{.}8$ ($12\overset{\mathrm{d}}{.}7$);
season 5, JD 2457500–2457760: $12\overset{\mathrm{d}}{.}7$ ($12\overset{\mathrm{d}}{.}7$);
season 6, JD 2457870–2458120: $13\overset{\mathrm{d}}{.}0$ ($12\overset{\mathrm{d}}{.}9$).

No cycle could be derived for season 1 (JD 2456190–2456280) due to the small number of observations. The mean cycle for all the ASAS-SN observations is estimated as $12\overset{\mathrm{d}}{.}3$ (or, using the Deeming method, as $12\overset{\mathrm{d}}{.}7$).

We could not determine mean cycles for the CSS data because of large time gaps between the observations.

According to our CCD data, the variability range is $14\overset{\mathrm{m}}{.}44-18\overset{\mathrm{m}}{.}1$ (B), $14\overset{\mathrm{m}}{.}36-17\overset{\mathrm{m}}{.}9$ (V); the full amplitude in the R band is 3.1 mag. The mean cycle is $11\overset{\mathrm{d}}{.}5$–$13^{\mathrm{d}}$(the Deeming method gives $12\overset{\mathrm{d}}{.}4$).

According to the GALEX catalog (Bianchi et al. 2011), 2MASS 23212116+3807563 is a blue star with a large UV excess (magnitudes $FUV = 15\overset{\mathrm{m}}{.}338$ and $NUV = 15\overset{\mathrm{m}}{.}333$, $FUV - NUV = 0.005$). From the 2MASS catalog $J - K = 0.748$. In our CCD observations, the mean color index is $B - V = 0.131$.

Judging from the detected photometric and physical properties, 2MASS 23212116 +3807563 as a cataclysmic variable star of the UG type in the GCVS classification (Samus et al. 2017).

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